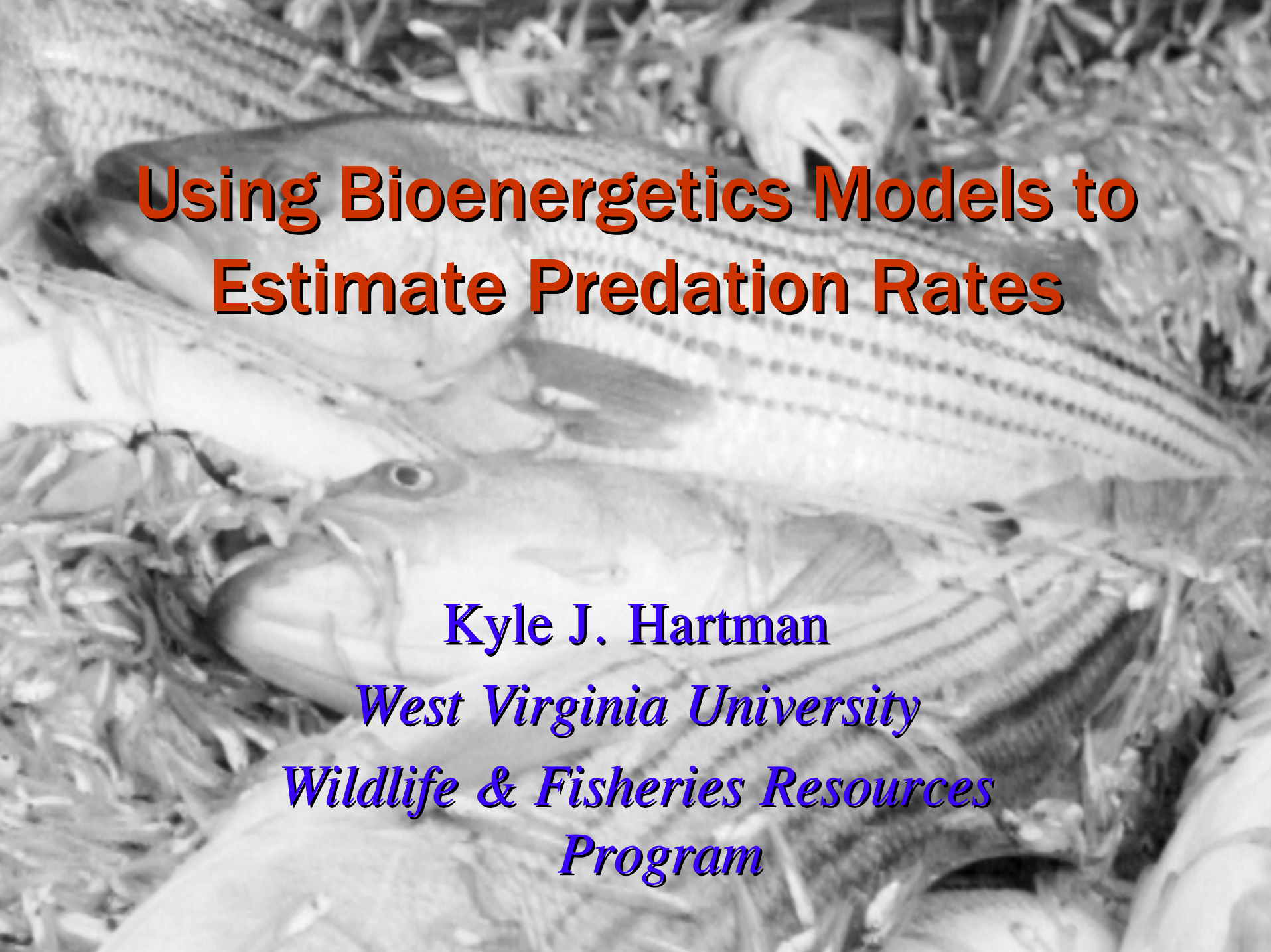

Using Bioenergetics Models to Estimate Predation Rates

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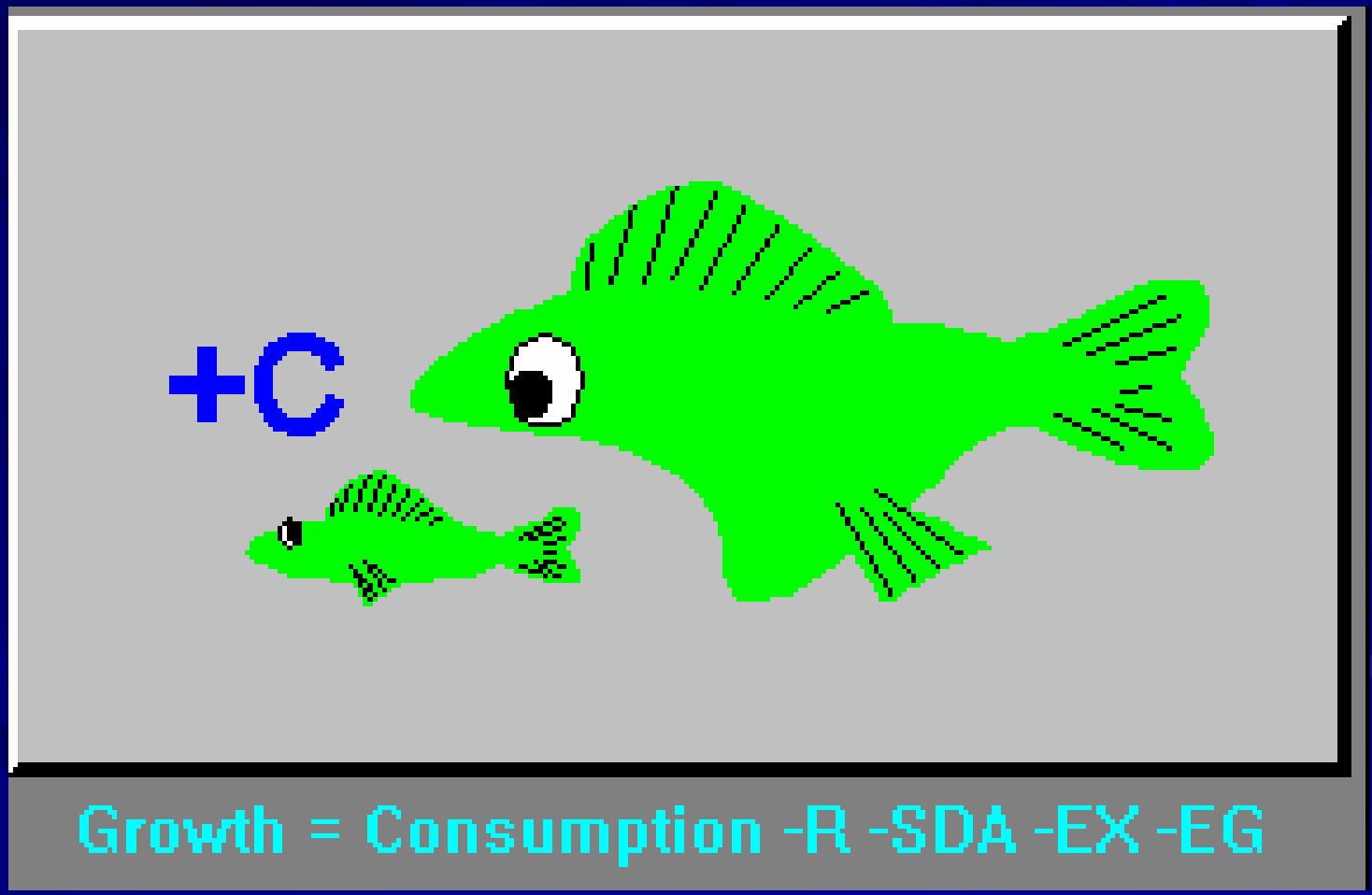
Outline

1) Background on bioenergetics.
2) Model requirements.
3) Predation case studies.
4) Strengths and weaknesses.

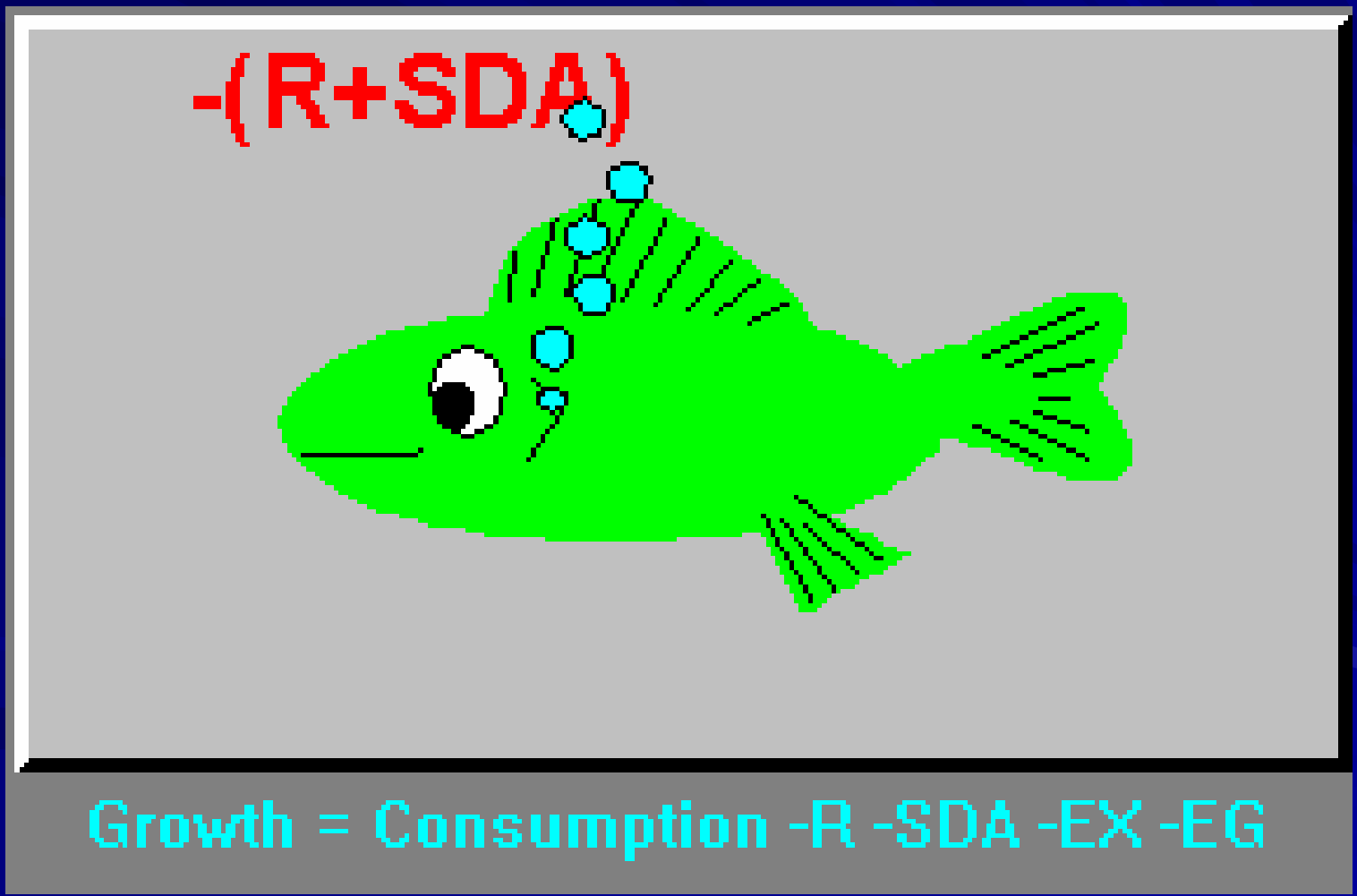
Bioenergetics principles

- Based on the 1st Law of Thermodynamics.
- *Energy cannot be created or destroyed…*

Balanced Energy Equation



Balanced Energy Equation



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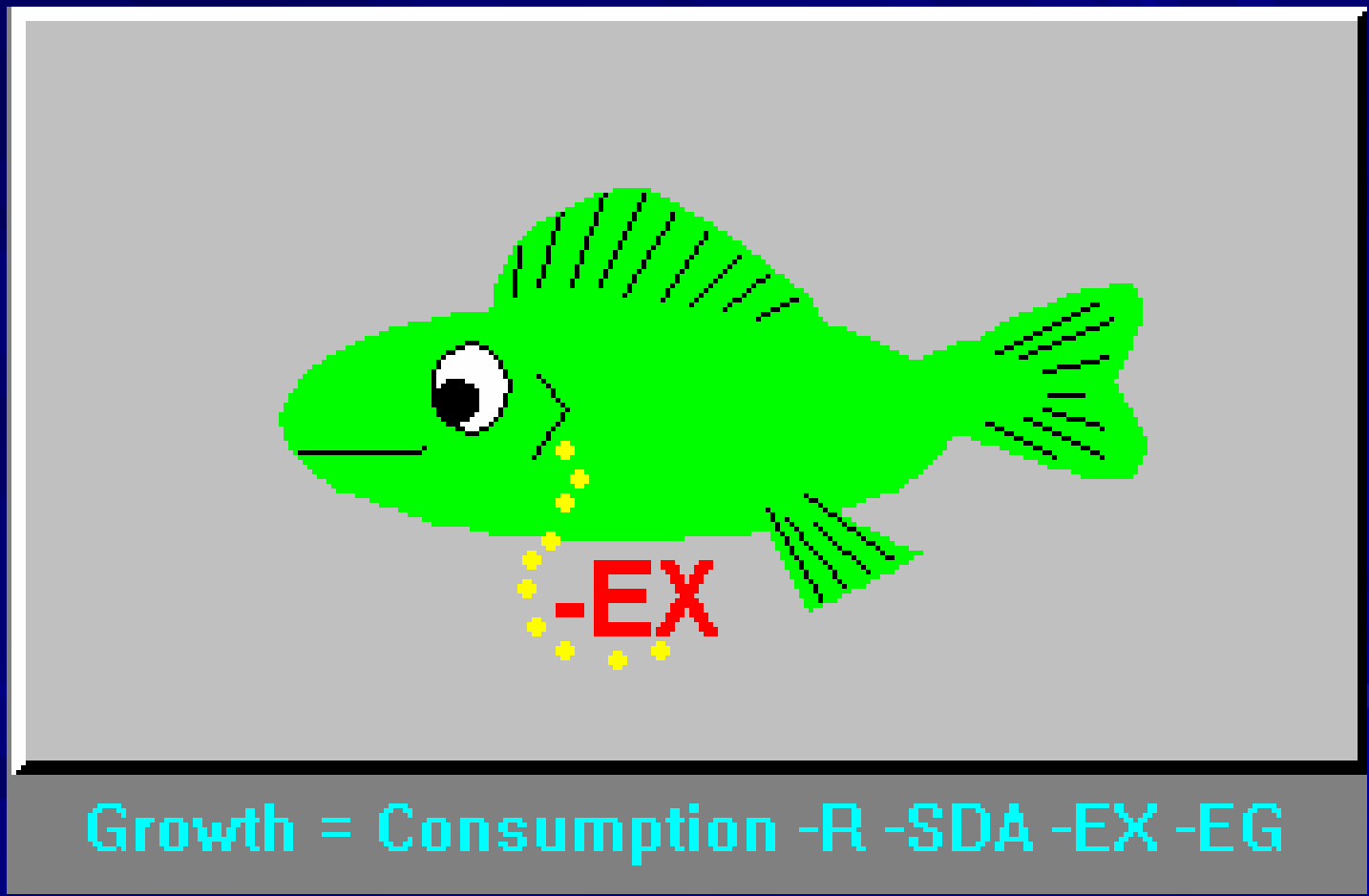

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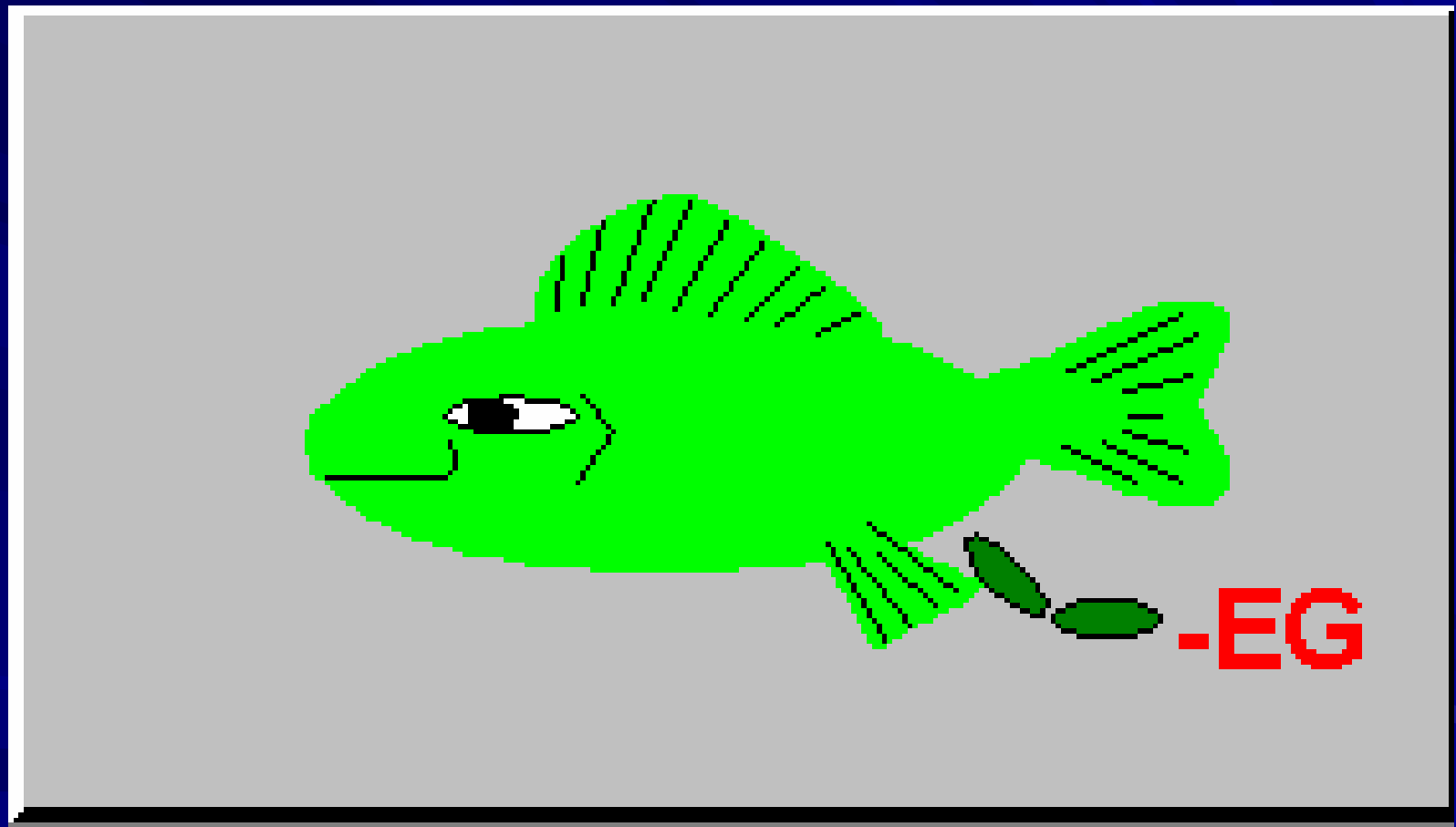
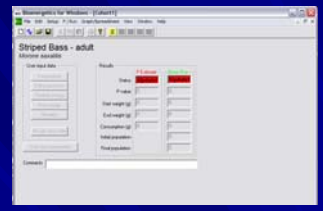


The “Wisconsin” Model



- Jim Kitchell et al. 1974 and 1977.
- Convenient computer software (v. 3.0 1997).

- Framework used to estimate predation by Great Lakes salmonids, prey fish, lamprey, walleye, etc.

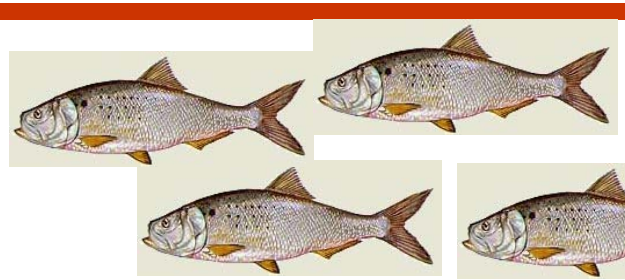
- Used to estimate predation by striped bass and other Atlantic coast predators.

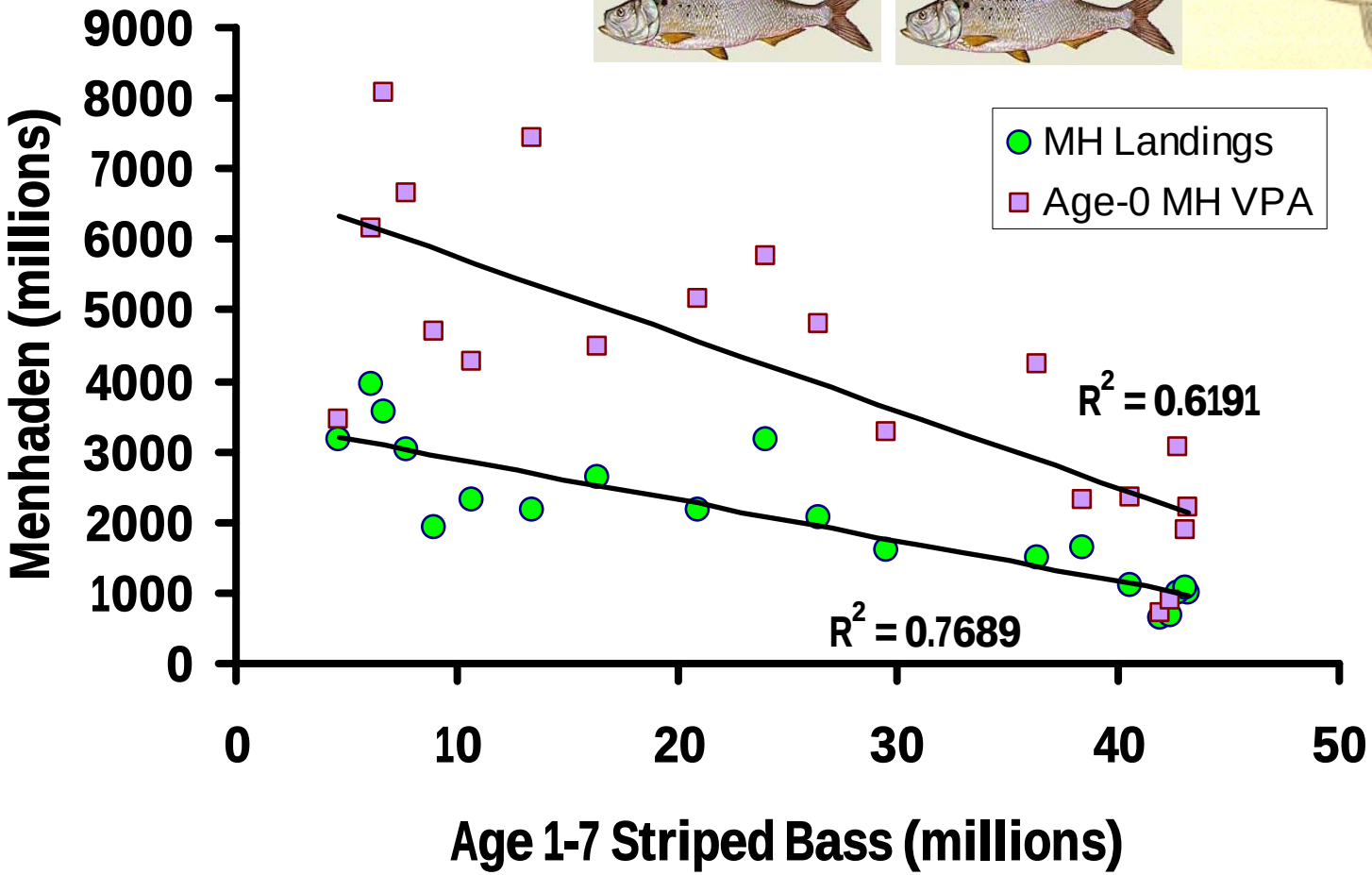
Basic model requirements

1. Measures of growth of average individual.
2. Water temperatures occupied by fish.
3. Diet composition (mass).
4. Energy content of predator and prey.
5. Population parameters (N, Z, I & E) – if applying to populations.

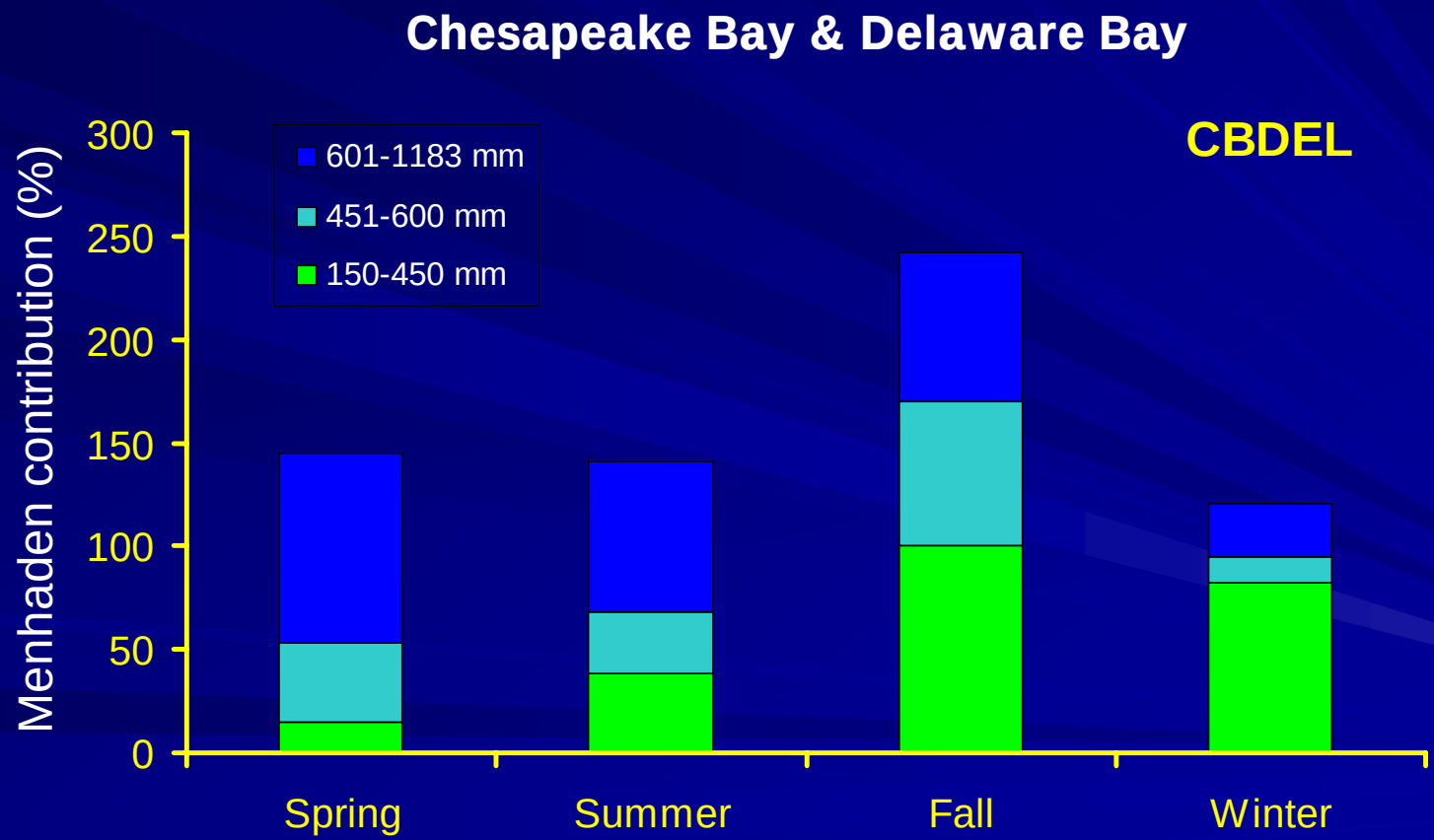
Coastal Striped Bass Case Study

In the mid-Atlantic – Concern that burgeoning striped bass pops were influencing Atlantic menhaden populations.





Atlantic menhaden are important in regional diets (Walters et al. 2003)



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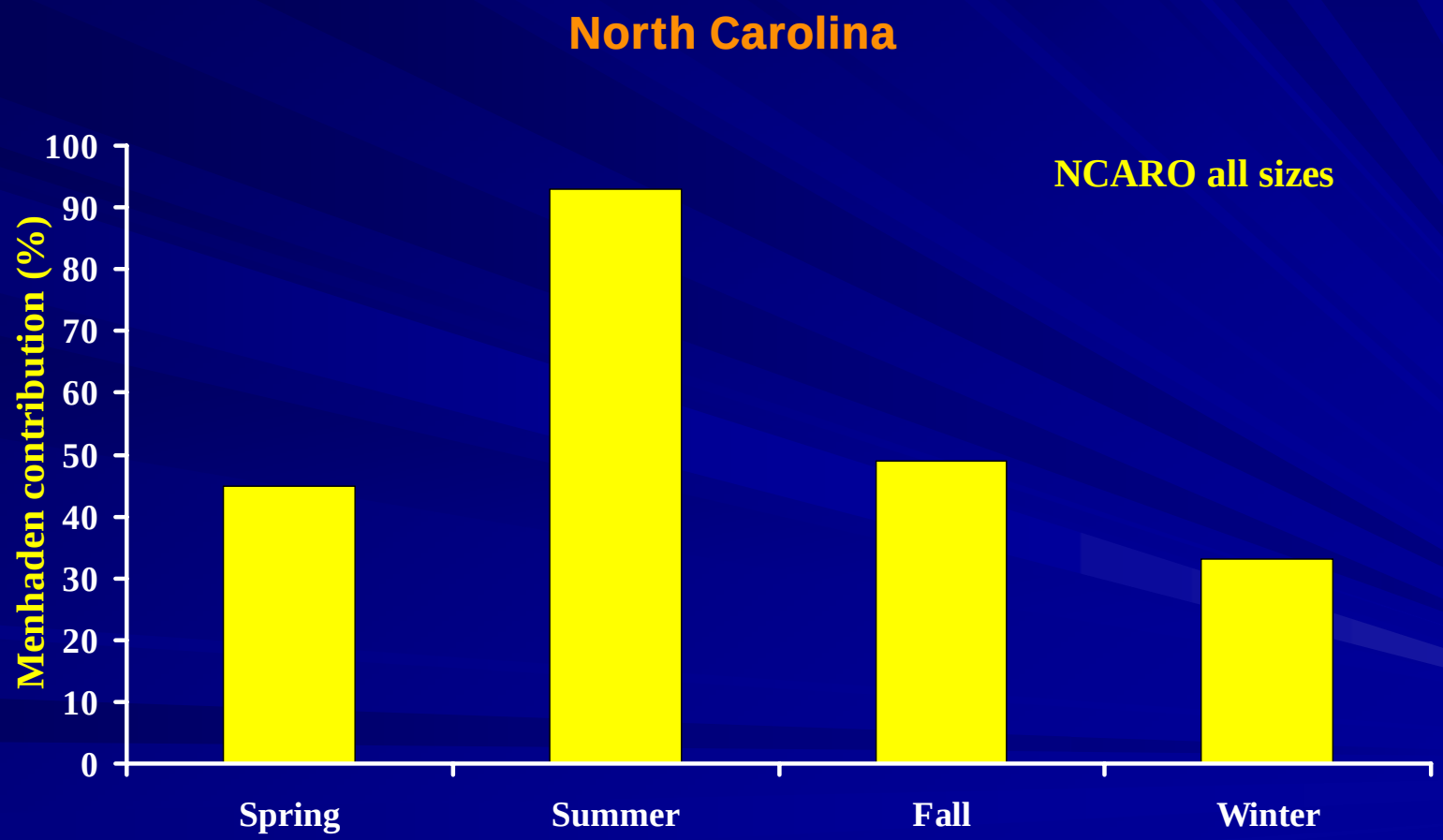


Several model analyses to evaluate predation by striped bass in Chesapeake Bay

Step 1. Estimating increases in SB predatory demand (1982-2001).

Step 2. Comparing Chesapeake Bay predatory demand (1991 vs. 2002) and evaluating importance of menhaden vs. alternate prey in "fattening" period.

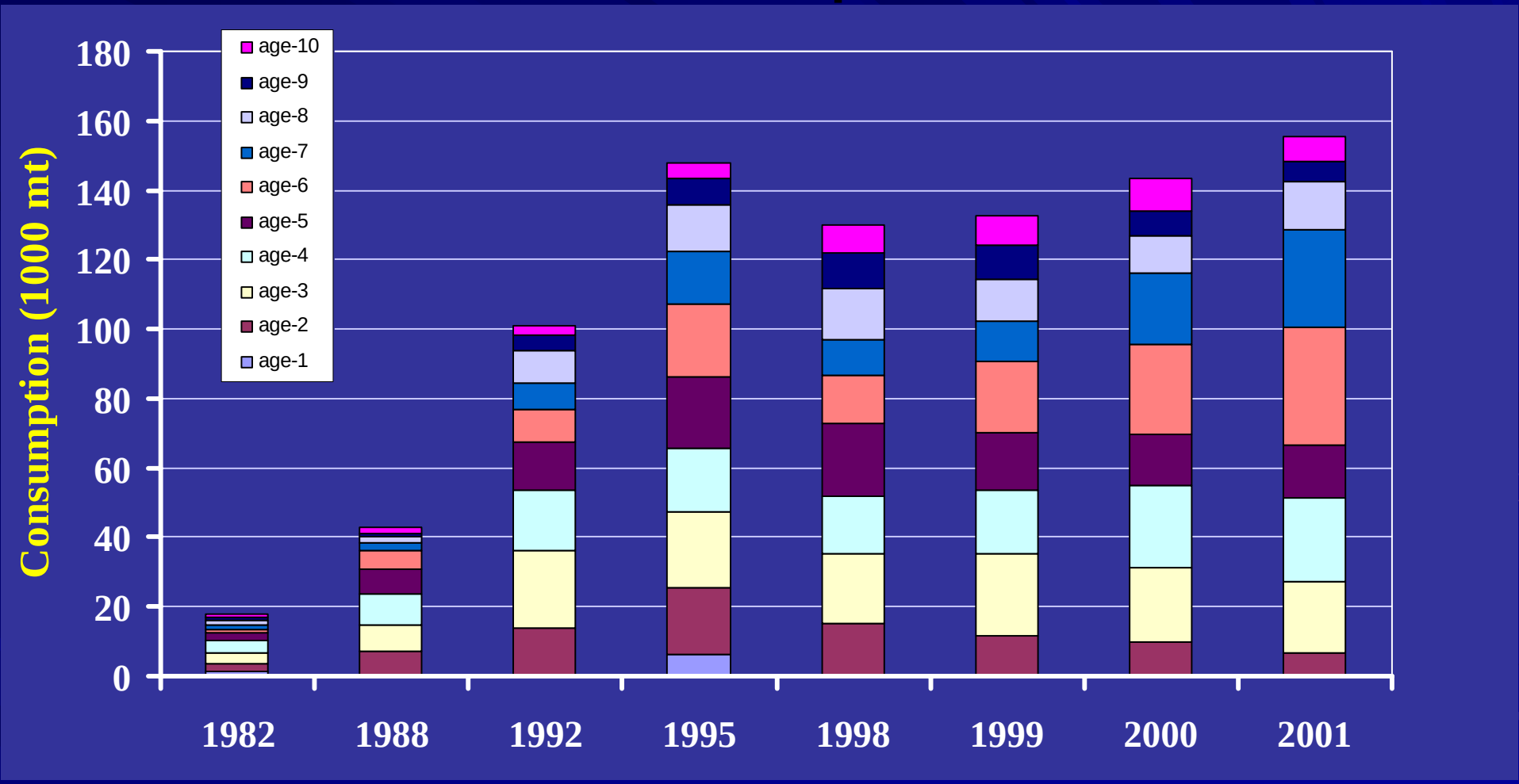
Step 3. Timing and magnitude of SB use of MH.

Step 4. Evaluating management actions upon predatory demand.

Coastwide Bioenergetics Modeling *Methods*

- Modeled coast wide popls. 1982-2001, ages 1-10.
- Used the Hartman & Brandt (1995) BM and energy densities.
- ASMFC (2003) mortality estimates.
- Water temperatures from coastal area (Hartman 2003).

Coastwide Population Consumption



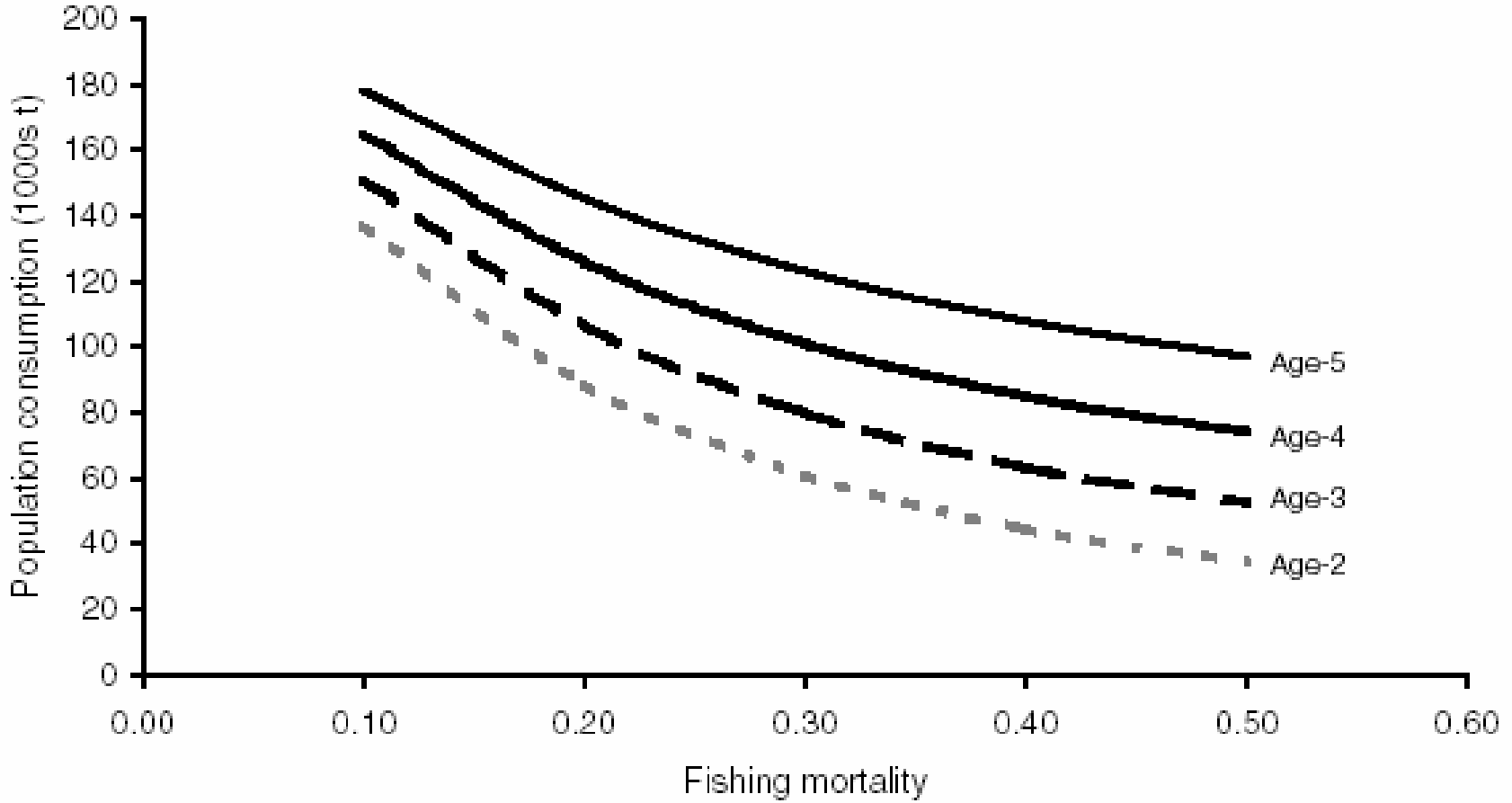
Coastal Predatory Demand increased

- Population level consumption increased 265% from 1982 to 1988.
- Consumption increased 227% from 1988 to 1992.

Population Consumption

- Peaked in 2001 (155,500 t)
- 8-fold increase from 1982 – 1995.
- SB consuming up to 57% of menhaden harvested per year (261,000 to 413,000 t).

Management approaches to reduce Predatory Demand



Management Options
Results

- Changing age-at-entry (AE) and fishing mortality (by increments of 0.10) had similar impacts on PD.
- Moving AE from age-5 to age-4 reduced PD 17% at intermediate F.
- Similar declines by increasing F from 0.25 to 0.35.

Strengths & Weaknesses

Strengths or Pluses

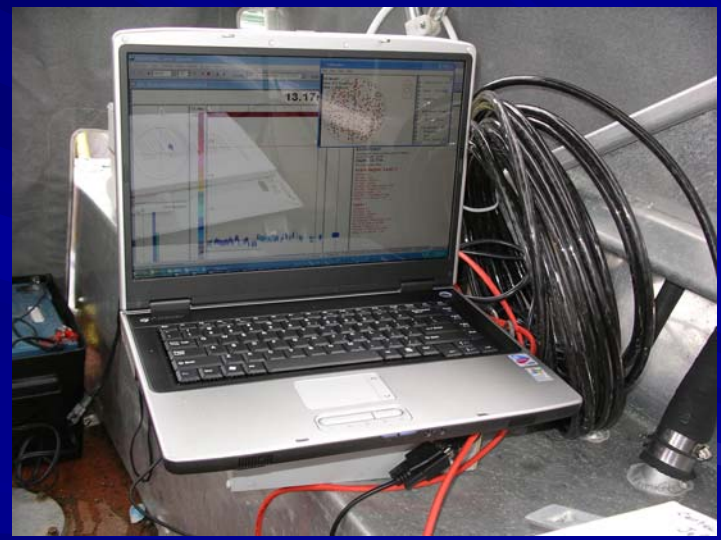
- Models have been validated for many species.
- Model already exists for striped bass.
- Much of the site-specific data needs may already be available:
  - Temperature
  - Diets
  - Growth?
  - Population parameters?

Weaknesses or Minuses

- Models are only as good as the inputs and assumptions.
- Most BM applications assume closed systems.

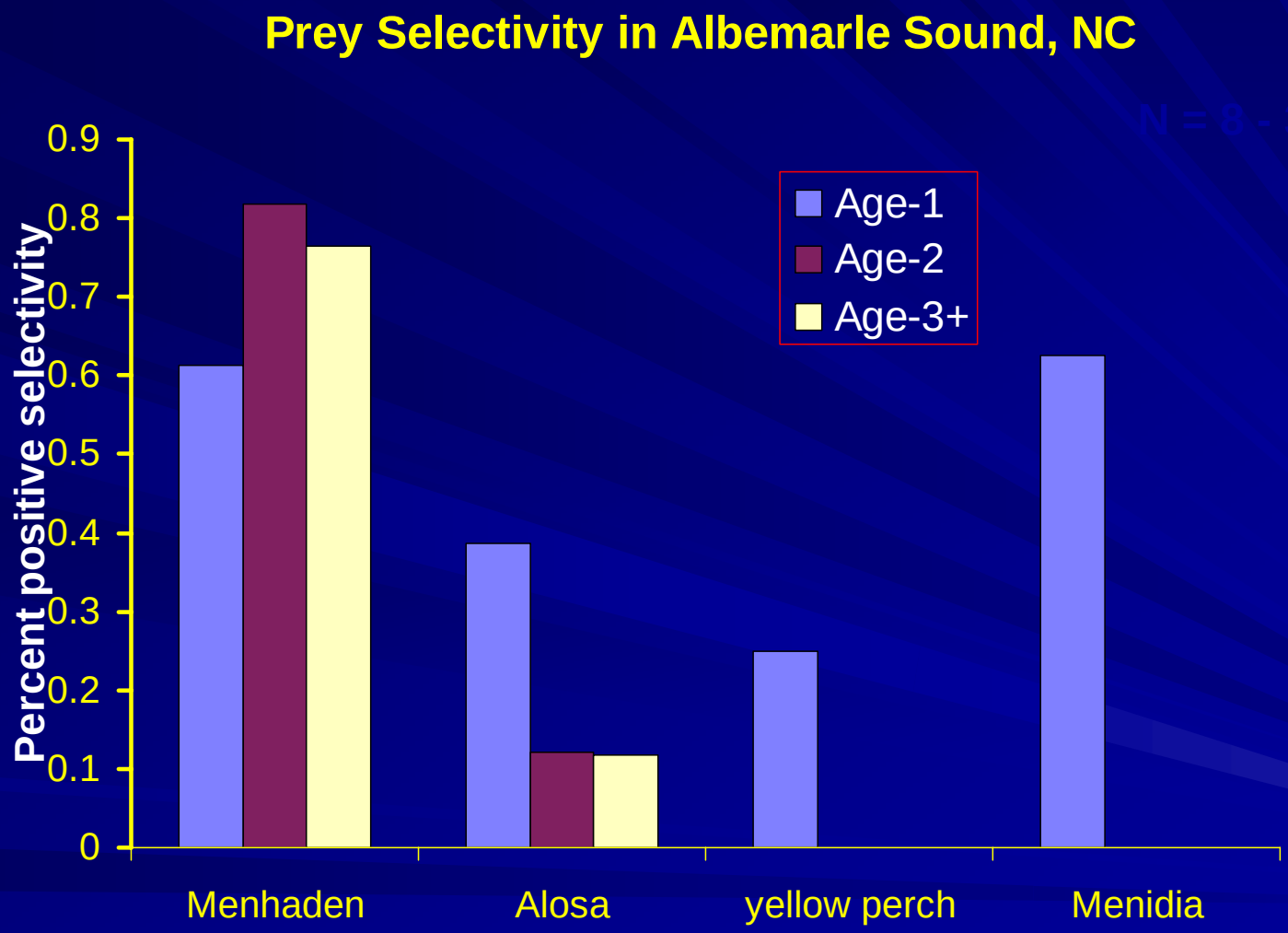
Final thoughts

- BMs have commonly been linked to more complex / dynamic models to address complex questions.



- E.g. IBMs, spatial models, etc.

SB select strongly for clupeid fishes.



** MH not selected for only in earliest [illegible]
selected for May thru July for [illegible]